

Towards Validating a Model for Assessing Team Tactical Decision Making

Joan H. Johnston

Joan.johnston@navy.mil

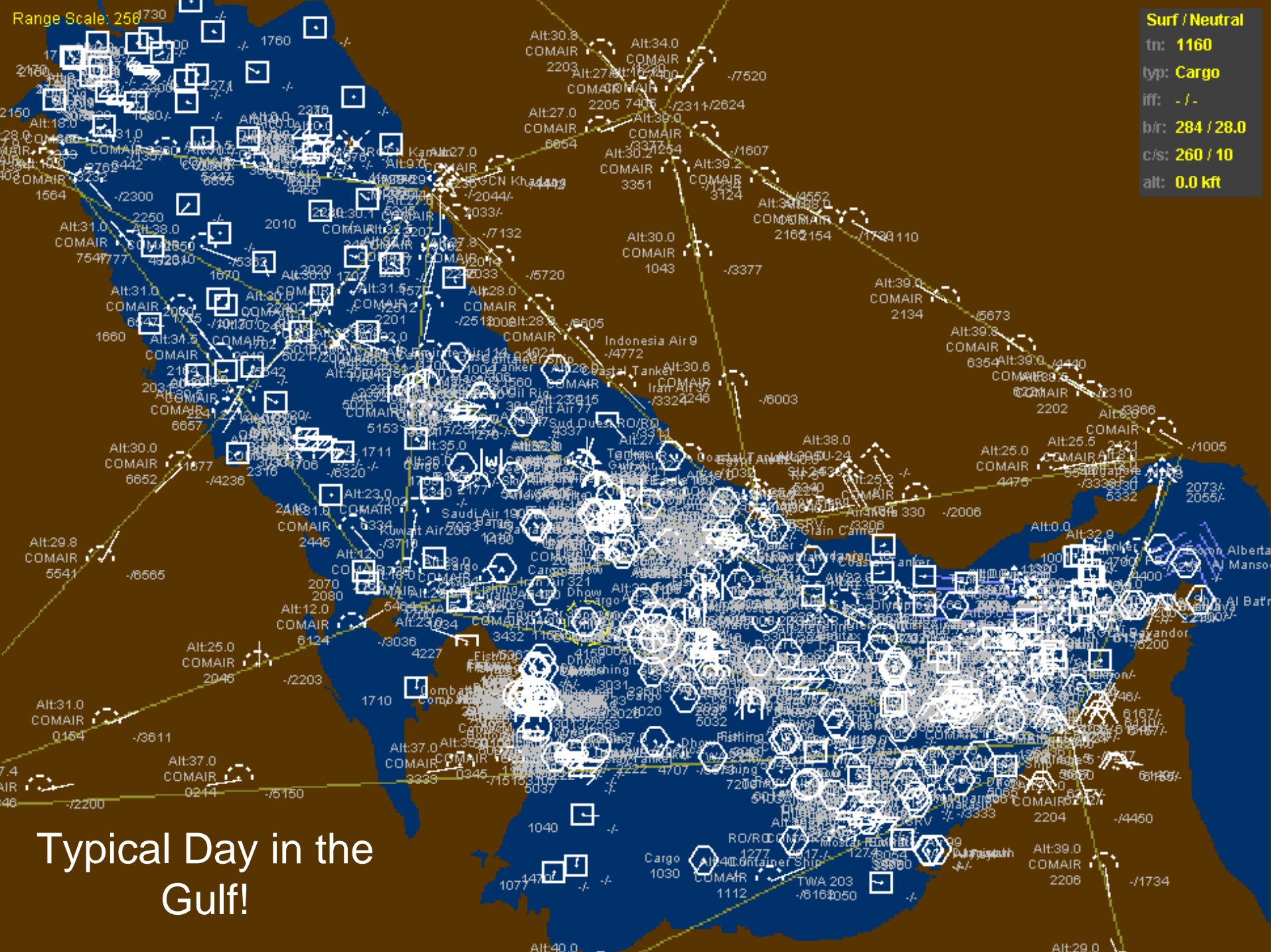
NAVAIR ORLANDO TRAINING SYSTEMS DIVISION

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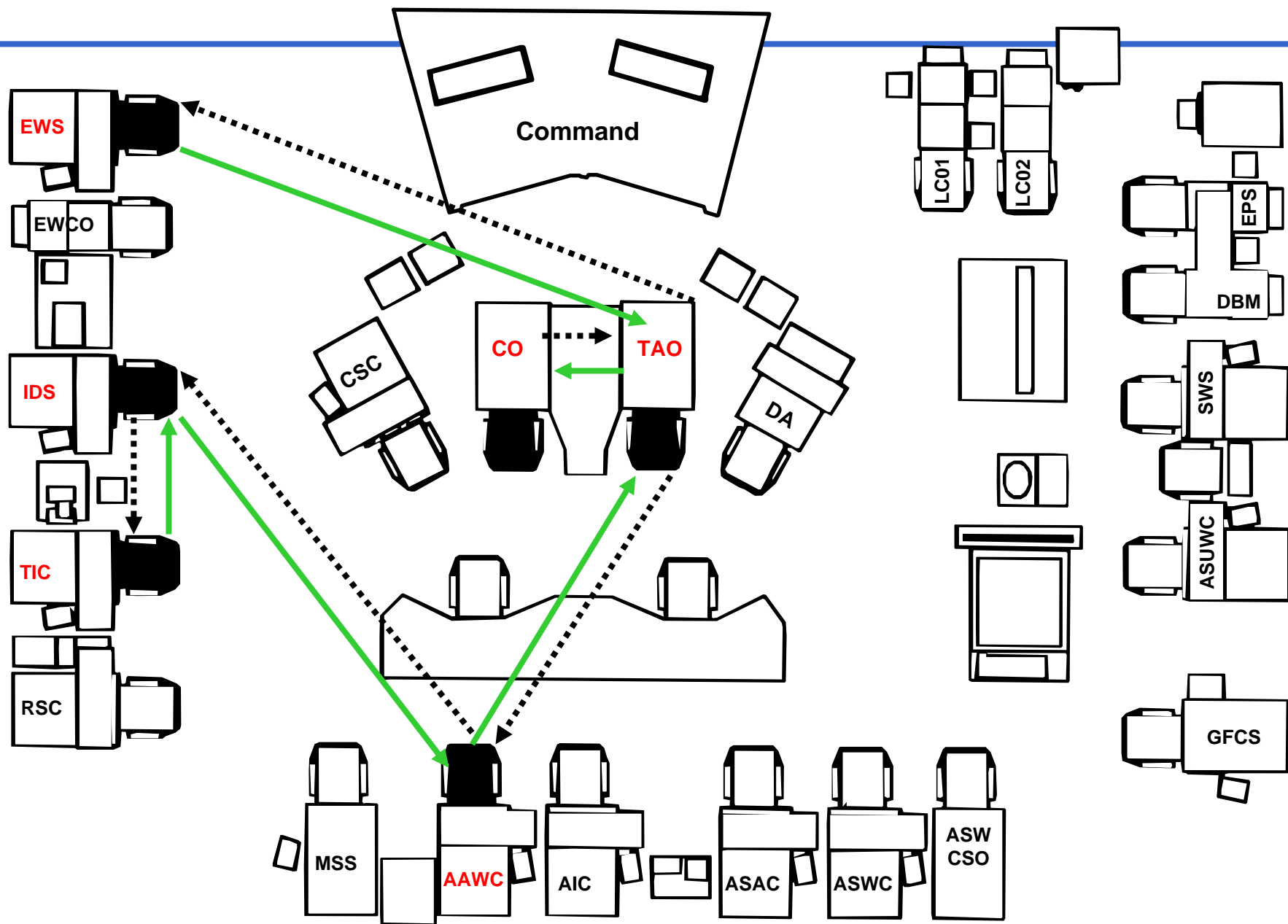
Introduction

- Current R&D Requirements: Debriefing Distributed Simulation-Based Exercises
 - Team Performance Assessment & Diagnosis Technologies
 - After Action Review Tools
- *Presentation: Validation of a Measure for Assessing and Diagnosing Team Tactical Decision Making*
- Background & Approach
 - Tactical Decision Making Under Stress (TADMUS) 6.2
 - Context: Combat Information Center Teams In Air Defense Operations
 - Objective: Enhance The Quality Of Decision-making In High Stress Environments Via:
 - Phase 1 Products:
 - + Decision Support Tools & Individual and Team Training Principles
 - Phase 2 Products:
 - + Principles for Integrating Training and Decision Support



Typical Day in the
Gulf!

Focus: Air Defense Warfare Team



Combat Display Overload

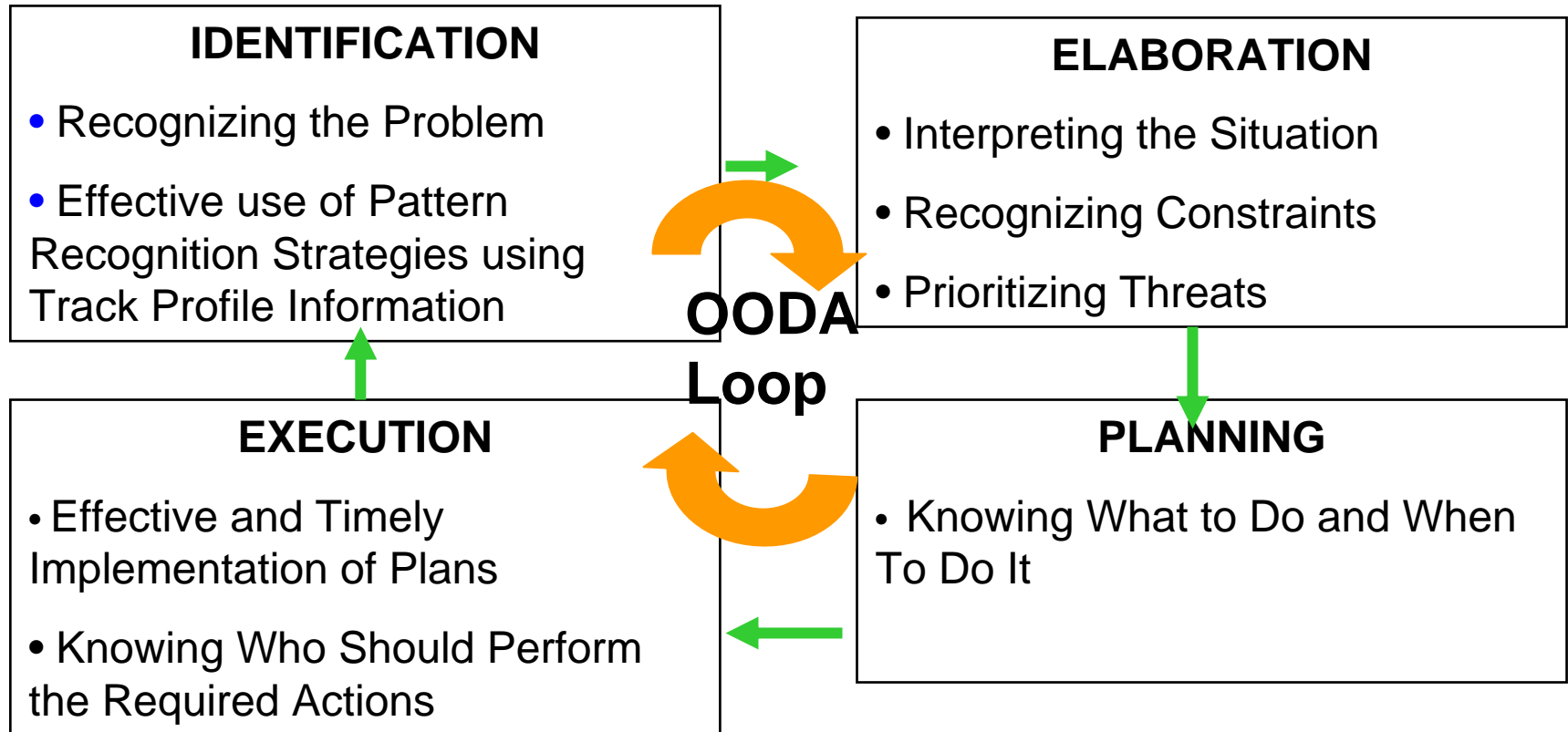


Displays & Training Don't Support Managing the Tactical Task

- Limitations in Memory
 - Forgetting or mixing up numbers assigned to radar contacts
 - Forgetting or confusing track kinematic data such as bearing, altitude, or range
- Memory Support Tools: Decision Biases
 - Persevering with incorrect threat assessments regardless of new information
 - Not considering all alternatives or hypotheses
- Memory Demands
 - Attention attenuation-competing cognitive tasks & team coordination requirements
 - Forgetting team communications
 - Not attending to team coordination requirements
- Team Coordination Requirements

Decision Making Dimensions

(Marshall et al., 1995)



DECISION-MAKING DIMENSIONS & TADMUS Decision Support System

Identification

Recognizing the Problem

Effective use of Pattern
Recognition Strategies
using Track Profile
Information

Planning

Knowing What to Do
and When To Do It

Identification

Planning & Execution

Effective and Timely
Implementation of
Plans

Elaboration

Interpreting the
Situation

Recognizing
Constraints

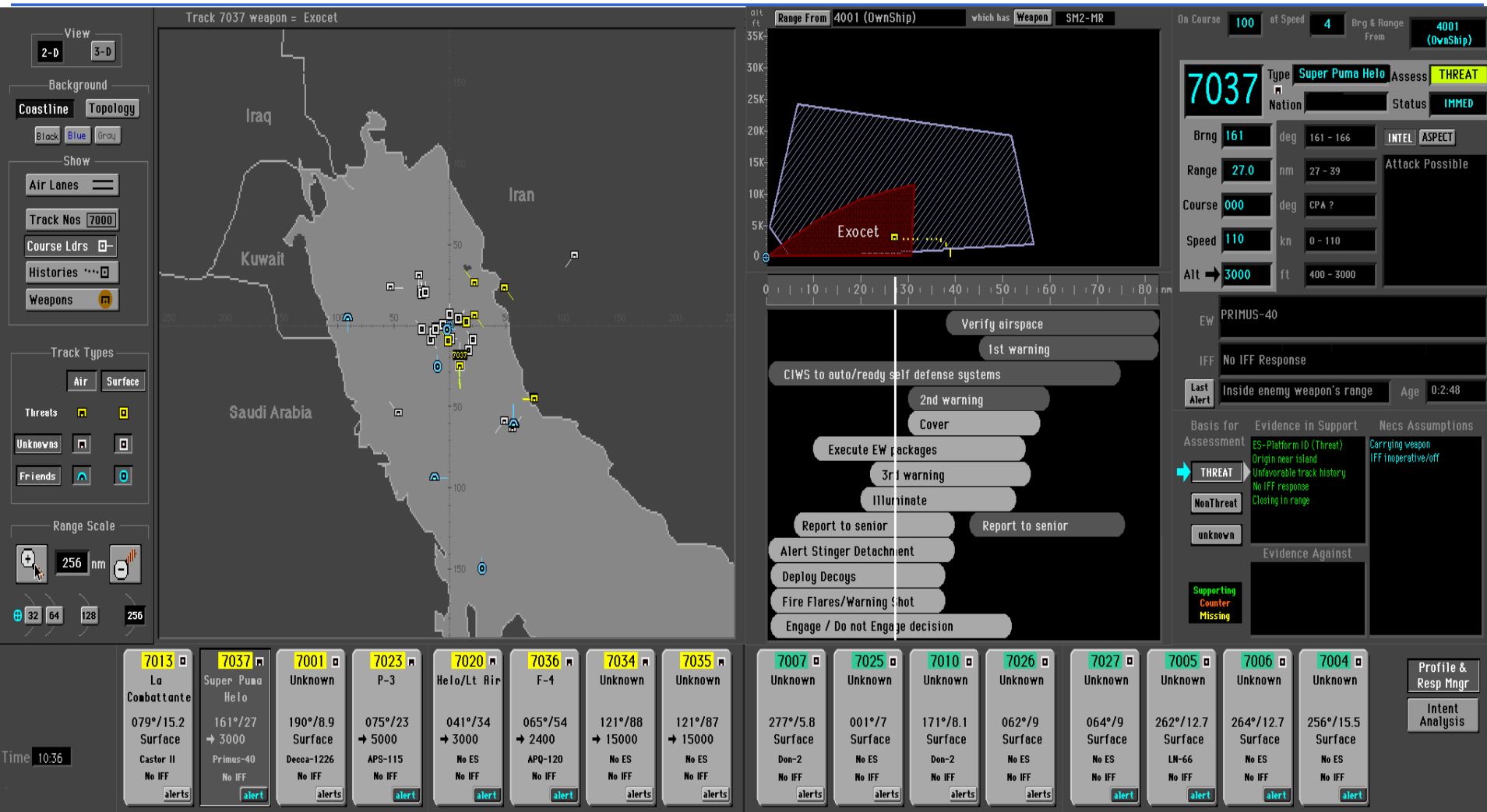
Prioritizing Threats

Identification

Identification

TADMUS DECISION SUPPORT SYSTEM (DSS)

Morrison et al. 1998



Track 7037 weapon = Exocet

View

2-D

3-D

Background

Coastline

Topology

Black

Blue

Gray

Show

Air Lanes



Track Nos

7000

Course Ldrs



Histories



Weapons



Track Types

Air

Surface

Threats



Unknowns



Friends



Range Scale



128 nm

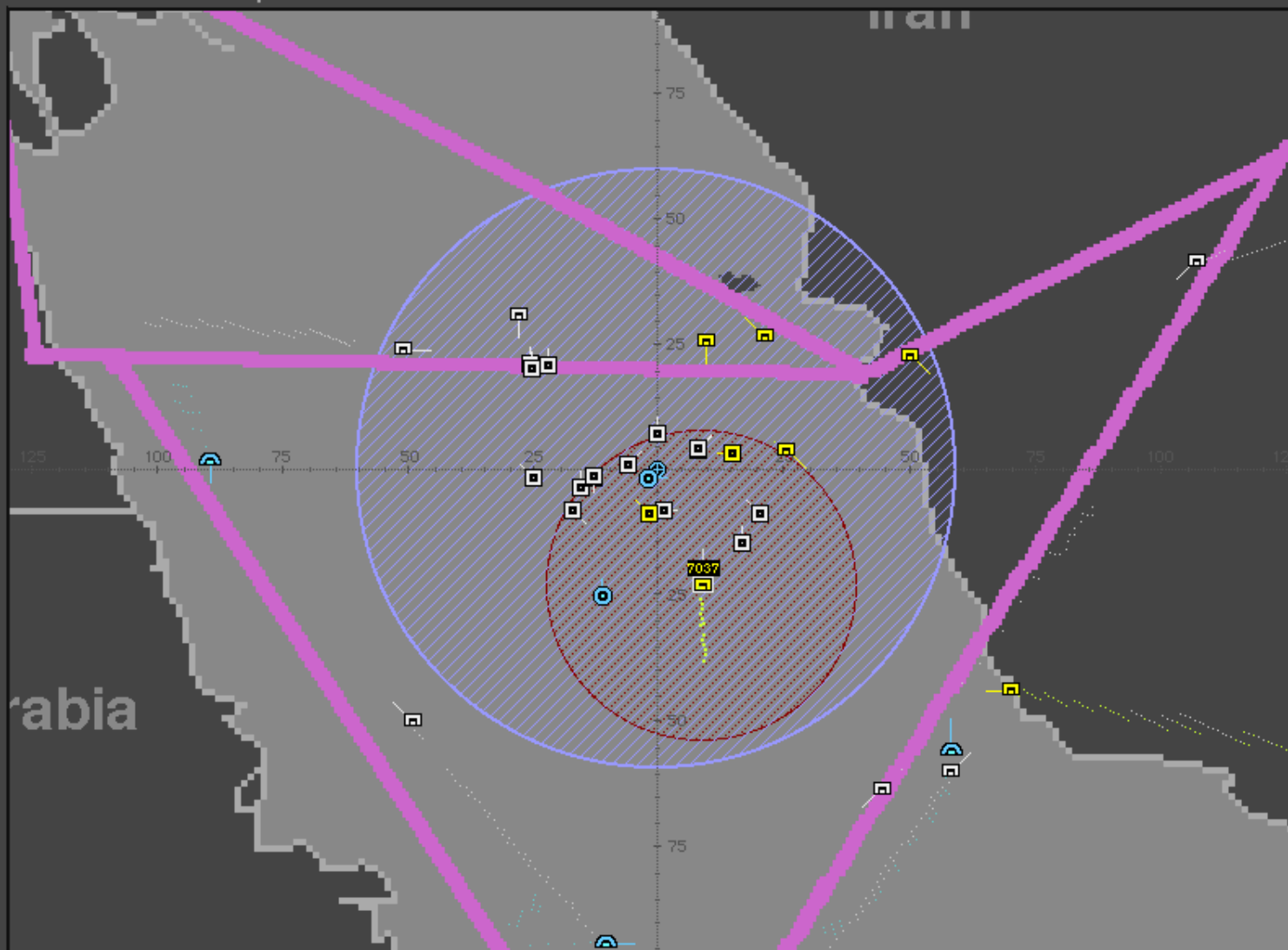


32

64

128

256



7013



La
Combattante

078°/15.1

Surface

Castor II

No IFF

alerts

7037



Super Puma
Helo

160°/25

→ 3000

Primus-40

No IFF

alert

7001



Unknown

190°/8.9

Surface

Decca-1226

No IFF

alerts

7023



P-3

081°/25

→ 5000

APS-115

No IFF

alert

7020



Helo/Lt Air

039°/34

→ 3000

No ES

No IFF

alert

7036



F-4

067°/55

→ 2400

APQ-120

No IFF

alert

7034



Unknown

122°/84

→ 15000

No ES

No IFF

alerts

7035



Unknown

122°/84

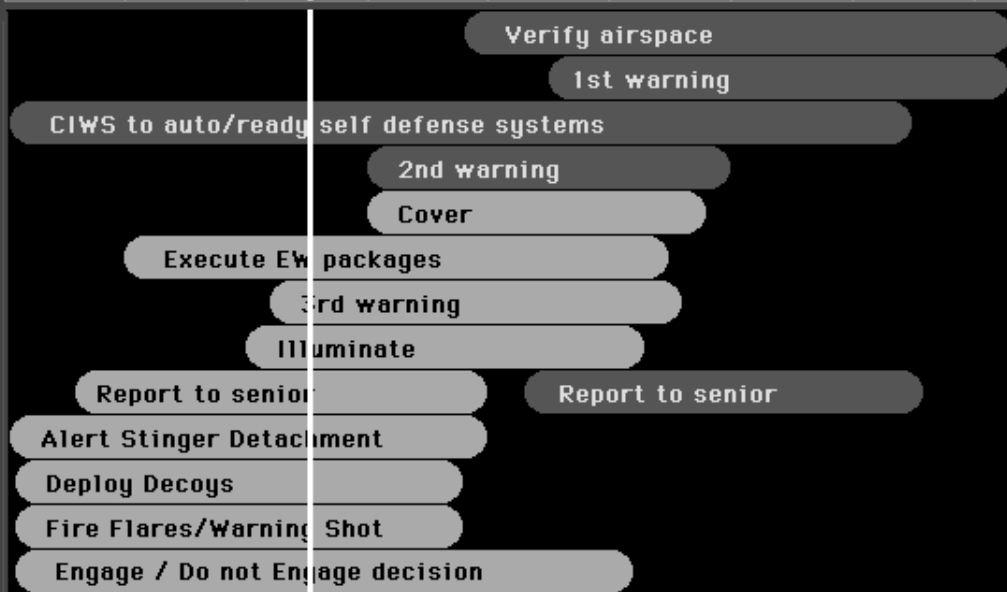
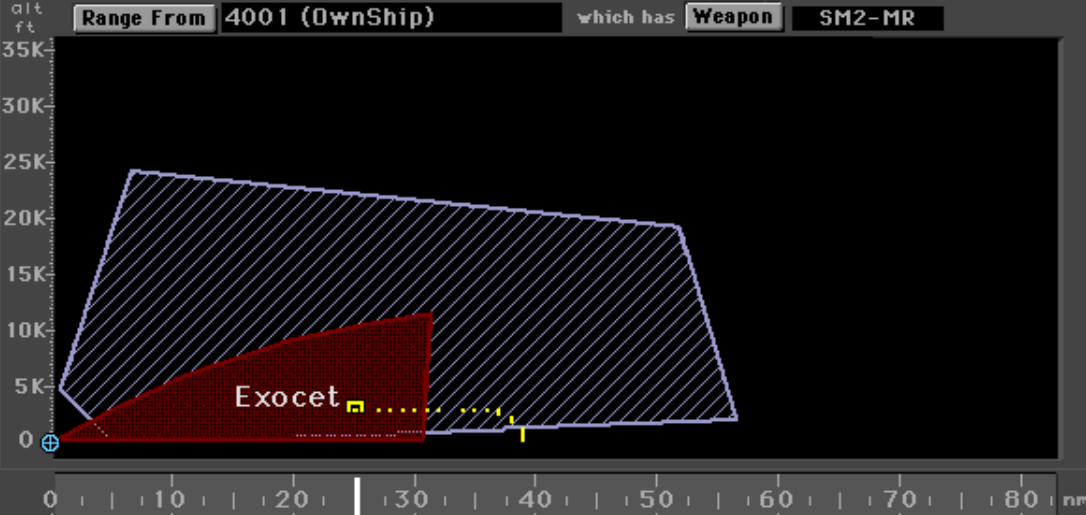
→ 15000

Cyrano-IV

No IFF

alerts

Time 11:18



On Course 100 at Speed 4 Brg & Range From 4001 (OwnShip)

7037 Type Super Puma Helo Assess THREAT
Nation Status IMMED

Brng 159 deg 159 - 166 INTEL ASPECT
Range 25.0 nm 25 - 39 Attack Possible
Course 000 deg CPA ?
Speed 110 kn 0 - 110
Alt 3000 ft 400 - 3000

EW PRIMUS-40

IFF No IFF Response

Last Alert Inside enemy weapon's range Age 0:3:48

Basis for Assessment Evidence in Support Nec's Assumptions

THREAT
NonThreat
unknown

ES-Platform ID (Threat)
Origin near island
Unfavorable track history
No IFF response
Closing in range

Carrying weapon
IFF inoperative/off

Evidence Against

Supporting
Counter
Missing

7035 Unknown 122°/82 → 15000 Cyrano-IV No IFF alerts	7007 Unknown 279°/5.8 Surface Don-2 No IFF alerts	7025 Unknown 001°/7 Surface No ES No IFF alerts	7010 Unknown 171°/8.1 Surface Don-2 No IFF alerts	7026 Unknown 063°/9 Surface No ES No IFF alerts	7027 Unknown 064°/9 Surface No ES No IFF alert	7006 Unknown 264°/12.7 Surface No ES No IFF alert	7005 Unknown 262°/12.8 Surface LN-66 No IFF alert
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Profile &
Resp Mgr

Intent
Analysis

TADMUS Training Strategies

(Cannon-Bowers & Salas, 1998)

- Scenario-Based Training/Event Based Approach (Johnston et al., 1998)
- Identification/Elaboration Cognitive Processes
 - Critical Thinking Training--Know Thyself... (Cohen et al., 1998)
- Planning & Execution Team Tasks: Knowing Who Should Perform The Required Actions
 - Team Dimensional Training (Smith-Jentsch et al., 1998)
 - Team Leader Training--The Blind Pass... (Tannenbaum et al., 1998)
 - Team Coordination Training--He Ain't Heavy...(Serfaty et al., 1998)
 - Team Self-Correction-- Replay in the Bar...(Smith-Jentsch et al., 1998)
 - Cross Training--Walking in Each Other's Shoes...(Blickensderfer et al., 1998)

PERFORMANCE MEASUREMENT SCHEME

P R O C E S S	INDIVIDUAL <ul style="list-style-type: none"> - Decision Making Processes - Task Strategy - Information Seeking <u><i>Behavior Observation Booklet</i></u> <u><i>Critical Thinking Strategies</i></u>	TEAM <ul style="list-style-type: none"> - Coordination Behaviors - Communication Flow - Team Strategies <u><i>Air Warfare Team Observation Measure</i></u> <u><i>Anticipation Ratio</i></u>
	O U T C O M E <ul style="list-style-type: none"> - Accuracy - Timeliness - Decision Biases <u><i>Sequenced Actions & Latencies Index</i></u> <u><i>Vocalized Priorities (SA)</i></u>	<ul style="list-style-type: none"> - Mission Effectiveness - Team Level Timeliness & Accuracy - Error Propagation <u><i>Air Warfare Team Performance Index</i></u>

DESCRIBE, EVALUATE, DIAGNOSE BEHAVIOR

TADMUS Final Demonstration

- *Intervention: Combined Impact of Training and DSS on Team Performance*
- Hypotheses:
 - Less Perceived Stress
 - Better Teamwork Performance
 - Better Critical Thinking Skills
 - Better Tactical Performance
 - *Teamwork is Related to Tactical Performance*
- *Integrated Training Approach Via Scenario-Based Training*
 - *Individual Skills Training*
 - Critical Thinking Skills Training (PC-Based)
 - Decision Support System (DSS) Tutorial
 - *Team Skills Training*
 - Team Dimensional Training (TDT):
 - + Facilitated Team Self-Correction with Event-Based Scenarios
 - Cross Training:
 - + Utilized DSS for AAR to Facilitate Discussion of Decision Making Processes

TADMUS Final Demonstration Approach

- Participants: Total of 16 Six-Person Teams (Surface Warfare Officer's School Department Head Classes) in control (8) and in experimental (8) conditions
- Design: Multiple Post-Test (Arabian Gulf Event-Based Scenarios) Counterbalanced
- Task: Air Defense Warfare (Decision Making Evaluation Facility for Tactical Teams)
- Individual and Team Measures
 - Stress: NASA TLX
 - Teamwork: ATOM
 - Team Tactical Decision Making (ATPI)
 - TAO Decision Making Priorities
 - Critical Thinking Indicators (under development)
- Recorded Team Voice Comms, Created Transcripts

DEFTT Lab at SWOS



Debrief/AAR Using the DSS



Research Problem:

Need Diagnostic Team Performance Assessment

Tools to Identify Critical Team Knowledge and Skill Deficits

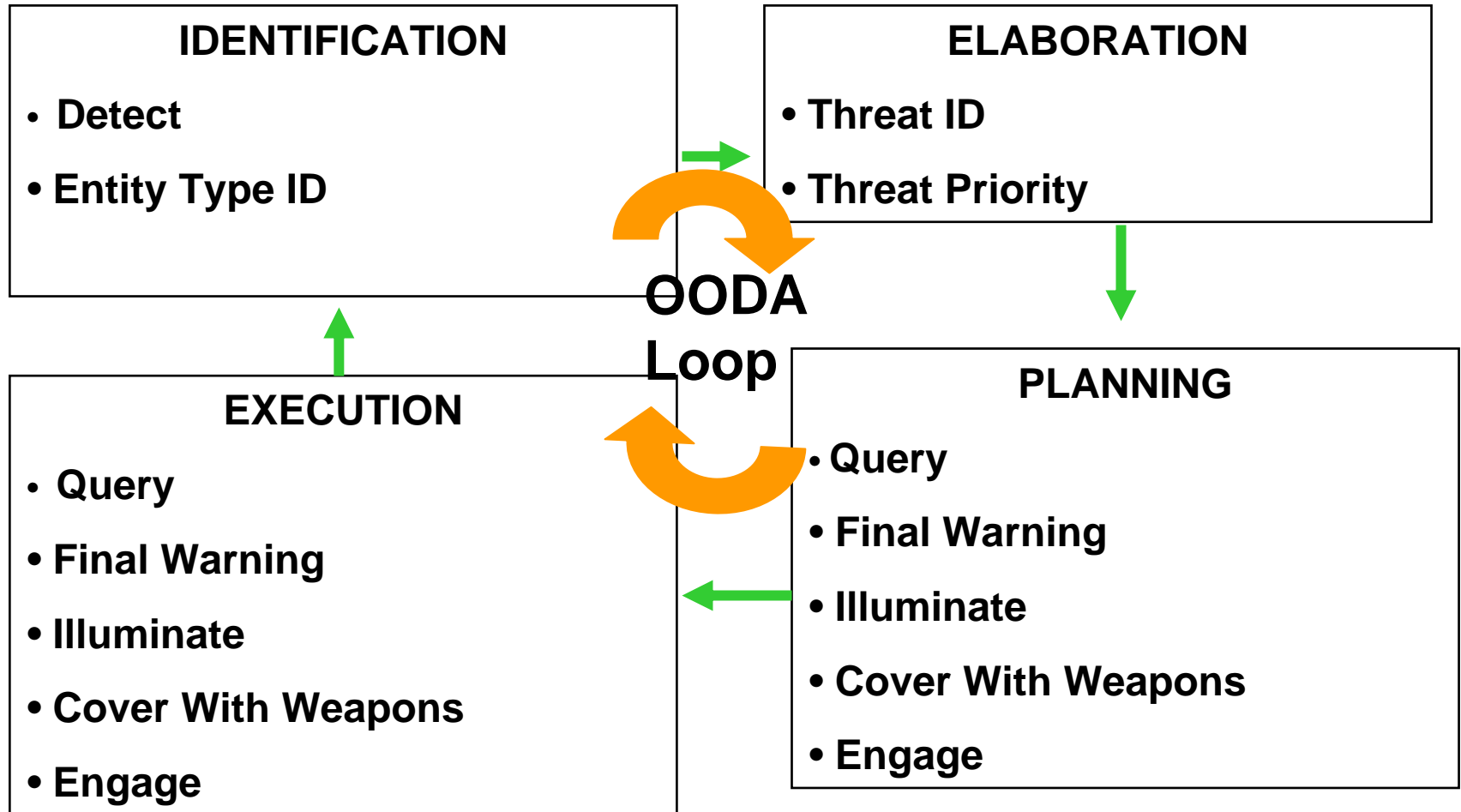
Hypotheses:

Measure of Team Taskwork, based on Marshall et al. model, will increase diagnosticity of team tactical decision making performance (Paris et al., 2001)

Using Taskwork & Teamwork measures will increase the diagnosticity of team performance for AAR (Johnston, Freeman, & Serfaty, 2003)

ID & Prioritization Actions	Planning & Execution Actions	Plan to Engage/Engage (What is typically discussed)
<ul style="list-style-type: none">• Recognizing the Problem (ID)• Effective use of Pattern Recognition Strategies using Track Profile Information (ID)• Interpreting the Situation (ELAB)• Recognizing Constraints (ELAB)• Prioritizing Threats (ELAB)	<ul style="list-style-type: none">• Knowing What to Do and When To Do It (Planning)• Effective and Timely Implementation of Plans (Execution)• <u>Knowing Who Should Perform the Required Actions (Execution)</u>	<ul style="list-style-type: none">• NMETLs• e.g., Proper Weapons Employment• Using proper weapons engagement procedures

Team Task Work: Detect-to-Engage Sequence (Paris, Johnston, & Reeves, 1998)



Air Warfare Team Performance Index

IDENTIFICATION					ELABORATION	EXECUTION														
						PLANNING														
Acq. Time Detec. Lost Brg/Rge	Track No. Craft Type	Detect	Entity Type ID		Threat ID /Threat Prioritization		Query			Final Warning			Illuminate			Cover w/ Weapons			Engage	
1:06 -- 030/77	7024 Comair	0	0	X	0	X	0	1	2	0	X _(E)	0	X _(E)	0	X _(E)	X _(E)	X _(E)	X _(E)		
							⇐ (7:00 E) ➤													
							⇐ (6:00 P) ➤													
1:06 -- 255/36	7023 Helo	0	0	X	0	X	0	1	2	0	X _(E)	0	X _(E)	0	X _(E)	0	X _(E)	X _(E)		
							⇐ (6:00 E) ➤													
							⇐ (5:00 P) ➤													
2:06 -- 030/76	7017 P-3	0	0	X	0	X	0	1	2	0	X _(E)	0	X _(E)	0	X _(E)	0	X _(E)	X _(E)		
							⇐ (15:30 E) ➤													
							⇐ (14:30 P) ➤													
6:06 -- 029/76	7027 F-4 (1)	0	0	X	0	X	0	1	2	0	X _(E)	0	X _(E)	0	X _(E)	0	X _(E)	X _(E)		
							⇐ (17:00 E) ➤													
							⇐ (16:00 P) ➤													
6:06 -- 029/76	7030 F-4 (2)	0	0	X	0	X	0	1	2	0	X _(E)	0	X _(E)	0	X _(E)	0	X _(E)	X _(E)		
							⇐ (23:00 E) ➤													
							⇐ (22:00 P) ➤													
12:06 -- 031/78	7034 Comair	0	0	X	0	X	0	1	2	0	X _(E)	0	X _(E)	0	X _(E)	0	X _(E)	X _(E)		
							⇐ (18:00 E) ➤													
							⇐ (17:00 P) ➤													

ATPI Analysis

- Created 6 ATPIs
 - Alpha &Tango training scenarios
 - Bravo, Charlie, Delta, India Experiment Scenarios
- Two SMEs used transcripts of team communications (obtained very close agreement)

<i>Summed Instances of Actions Across 4 Test Scenarios</i>	Summed ID & Elaboration Actions	Summed Planning & Execution Actions	Plan to Engage and Engage Actions
Tactical A/C	<ul style="list-style-type: none"> • Correct • Correct, But Late • Incorrect (Wrong/Missing) 	<ul style="list-style-type: none"> • Correct • Correct, But Late • Incorrect (Wrong/Missing) 	<ul style="list-style-type: none"> • Correct • Correct, But Late • Incorrect (Wrong/Missing)
Commercial A/C	<ul style="list-style-type: none"> • Correct • Correct, But Late • Incorrect (Wrong/Missing) 	<ul style="list-style-type: none"> • Correct • Correct, But Late • Incorrect (Wrong/Missing) 	Incorrect

TEAMWORK DIMENSIONS: PROCESSES

(Smith-Jentsch et al., 1998)

INFO EXCHANGE

- *Communication that promotes a team awareness of the surrounding environment, both internal and external to the team.*
- *Timely and accurate reporting of deviations and/or potential problems*

COMMUNICATION

- Clear and efficient exchange of relevant information.
- Using proper terminology, standard procedures for external communications, and an appropriate tone of voice.

SUPPORTING BEHAVIOR

- Monitoring the activities of other team members, taking action to correct errors, giving and receiving feedback in a nondefensive manner
- Providing and seeking assistance or backup when needed.

INITIATIVE/LEADERSHIP

- Providing needed guidance to other team members; helping team members focus their activities appropriately and anticipate tasks that should be performed;
- Providing instruction to other team members to enable team to perform or complete their tasks. Any team member can perform initiative / leadership functions.

Air Warfare Team Observation Measure (ATOM)

Example of Information Exchange for Evaluation

Frequency of Seeking sources - How many times did the team members proactively ask for information from multiple sources in order to establish an accurate assessment of the situation. These sources may be internal or external to the team and may include written documentation.

None = Seeking information is a real weakness for this team

1-2 times= Seeking Info is adequate for this team

3 or more times= Seeking Information is a Strength for this team

Air Warfare Team Observation Measure (ATOM)

Example of Information Exchange for Training

Anchored Scale for Seeking sources - Proactively asking for information from multiple sources in order to establish an accurate assessment of the situation. These sources may be internal or external to the team and may include written documentation.

1

2

3

4

5

Seeking information
a real weakness
for this team.

Seeking information is
is a real strength for
this team.

ATPI Outcomes

Number of Tactical Engagements	Correct Plan to Engage IAW ROE	Correct Engage IAW ROE	Plan to Engage not IAW ROE	Engage not IAW ROE
<u>Control</u> Tactical Commercial	<ul style="list-style-type: none"> • 7 • N/A 	<ul style="list-style-type: none"> • 6 • N/A 	<ul style="list-style-type: none"> • 10 (9 teams) • 1 	<ul style="list-style-type: none"> • 7 (6 teams) • 0
<u>Expt'l</u> Tactical Commercial	<ul style="list-style-type: none"> • 7 • N/A 	<ul style="list-style-type: none"> • 6 • N/A 	<ul style="list-style-type: none"> • 8 (7 teams) • 0 	<ul style="list-style-type: none"> • 6 (5 teams) • 0

ATPI: Team Task Processes

	ID & Elaboration Tactical Actions IAW ROE Percent of Possible Correct + Correct, But Late	Planning & Execution Actions IAW ROE Percent of Possible Correct + Correct, But Late	Number of Instances of Incorrect Planning & Execution Actions
<u>Control</u> Tactical	• 83 (range 78-89)	• 30 (range 25-41)*	• 0
Commercial	• 68 (range 48-83)	• 19 (range 0-45)	• 16 (6 teams)
<u>Expt'l</u> Tactical	• 85 (range 80-88)	• 36 (range 22-47)*	• 9 (6 teams)
Commercial	• 54 (range 29-71)	• 22 (range 5-45)	• 11 (4 teams)

* Problem appears to be NOT taking action

Initial Results:

Relationship of Teamwork and Taskwork

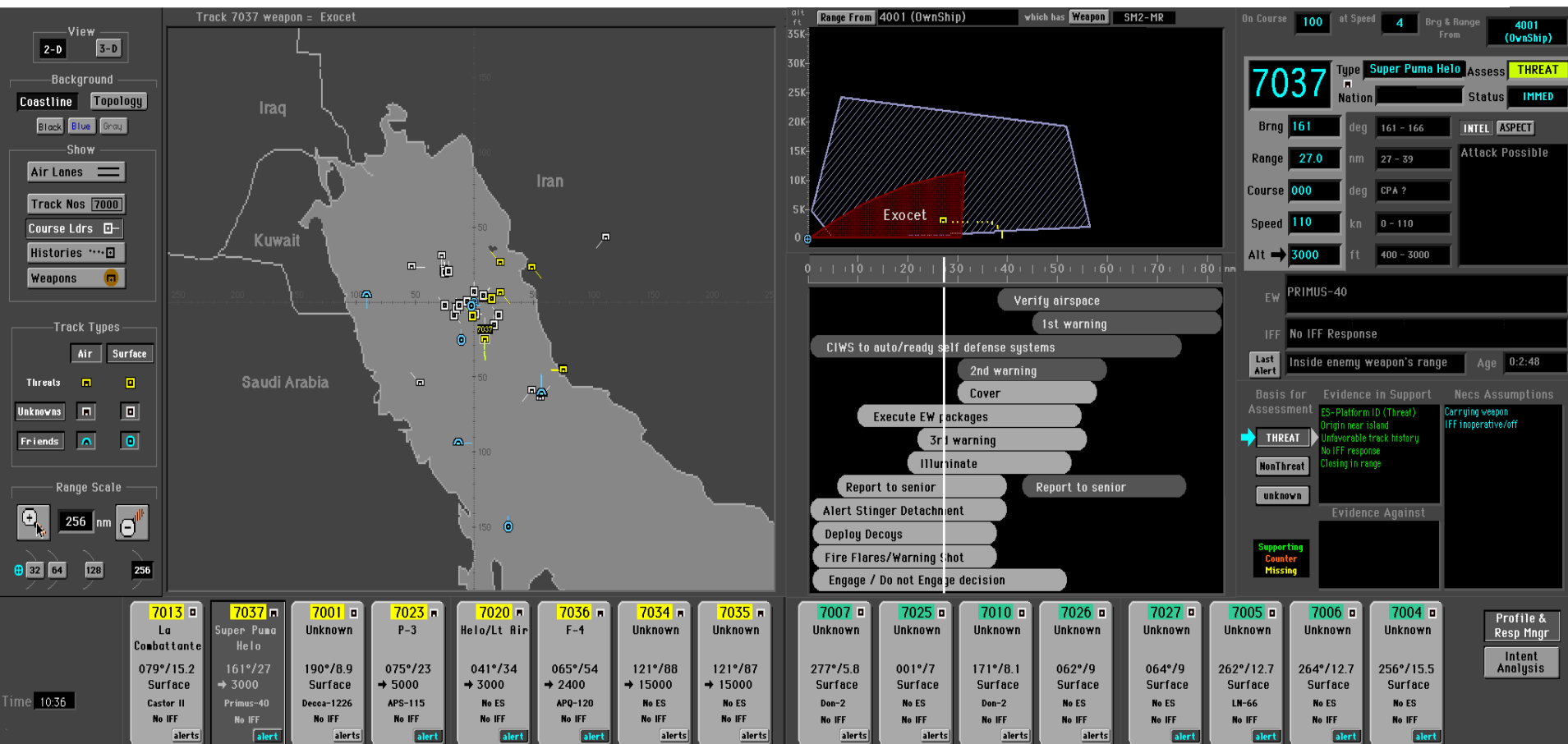
- DSS/Trained Teams Achieved Significantly Better ($p < .001$) Teamwork Performance (about 11% better after each scenario), than teams in the control condition
 - In Preparation For Potentially Hostile Tactical Aircraft, DSS/Trained Teams
 - Showed a trend in performing more correct actions across ID/ELAB/Planning/Exec ($p = .07$), but no correlation with teamwork ($r = .260$, n.s.) +
 - Showed a trend in waiting longer (a few seconds) across ID/ELAB/Planning/Exec, but performed more correct actions (much greater variability in performance than control condition) ($p < .1$). Correlation with teamwork was .418, but n.s. +
 - Waited longer (a few seconds), but performed *significantly* more correct planning/execution actions ($p < .005$). *Significant* correlation with teamwork performance ($r = .532^*$) +
- + Pooled Within Groups Correlation (Across Both Conditions) b/w Teamwork and ATP metrics ($.426^*$, $p < .05$, $df = 14$)

After Action Review

ID & Prioritization Actions	Planning & Execution Actions	Plan to Engage/Engage (Currently what gets discussed)
<ul style="list-style-type: none"> • Recognizing the Problem • Effective use of Pattern Recognition Strategies using Track Profile Information • Interpreting the Situation • Recognizing Constraints • Prioritizing Threats 	<ul style="list-style-type: none"> • Knowing What to Do and When To Do It • Effective and Timely Implementation of Plans • Knowing Who Should Perform the Required Actions—Teamwork Implicated Here 	<ul style="list-style-type: none"> • NMETLs • e.g., Proper Weapons Employment • e.g., Using proper weapons engagement procedures • Proper Operation of Radar System

Team Self Correction in AAR Can Focus on Planning & Execution Actions, to Rapidly Narrowing the Focus on Specific Knowledge and Skill Deficiencies

- GUI Concepts for AAR on Team Decision Making
 - Replay of Training Ground Truth
 - Expected Team Performance Compared with Actual Team Performance
 - Voice Reports and Watchstander Actions Incorporated Into Replay
 - Review of Events Walk Through to Address:
 - Team ID/ELAB Processes
 - + Basis for Assessment
 - + Track Priorities
 - Team Planning/Execution Processes Based on Task Manager Results



Selected References

- Johnston, J.H., Fiore, S., Paris, C., & Smith, C.A.P. (2004) Application of Cognitive Load Theory to Developing a Measure of Team Decision Efficiency. Under review at the Journal of Military Psychology.
- Marshall, S. P. (1995). Schemas in problem-solving. New York: Cambridge University Press, 1995.
- Morrison, J.G., Kelly, R.T., Moore, R.A., & Hutchins, S.G. (1998). Implications of decision-making research on decision support and displays. In J.A. Cannon-Bowers & E. Salas (Eds.), Decision Making Under Stress: Implications for Individual and Team Training.
- Paris, C. R., Johnston, J. H., & Reeves, D. (2000). A schema-based approach to measuring team decision-making in a Navy combat information center. In C. McCann & R. Pigeau (Eds.), The human in command: Exploring the Modern Military Experience (pp. 263-278). New York: Kluwer Academic/Plenum Publishers.
- Smith, C.A.P., J. Johnston, and C. Paris (2004). Decision Support for Air Warfare: Detection of Deceptive Threats, Group Decision and Negotiation, 13,129-148.